This document is guaranteed to be current only to issue date.

Some Mars Global Surveyor documents that relate to flight operations are under revision to accommodate the recently modified mission plan.

Documents that describe the attributes of the MGS spacecraft are generally up-to-date.

542-409, Volume 6, Part 3

Mars Global Surveyor

Mission Operations Specifications

Volume 6: Test Plan

Part 3: Mission Operations System Compatibility

Final

March 13, 1996

Jet Propulsion Laboratory
California Institute of Technology

JPL D-12369, Volume 6, Part 3

542-409, Vol. 6, Part 3

Mars Global Surveyor

Mission Operations System Compatibility Test Plan

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JPL D-12369, Volume 6, Part 3

13 March, 1996
Final

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1.0 PURPOSE AND SCOPE

The purpose of this document is to specify the objectives, and provide a high level description, of the Mission Operations System Compatibility (MOS-C) test program. In addition, this document identifies the test participants and their roles and responsibilities. Finally, the schedule for the execution of the MOS-C test program is included.

The MOS-C test program is conducted by the project to demonstrate operational compatibility between the MGS S/C and the Mission Operations System (MOS) utilizing critical sequences on the spacecraft while it is at the Lockheed Martin Astronautics (LMA) Facility in Denver. Also End-to-End compatibility will be demonstrated between the Deep Space Network (DSN) and the Mars Global Surveyor (MGS) spacecraft while the spacecraft is located at the Kennedy Space Center (KSC).

1.1 Reference Documents

The following documents provide requirements and support information used in the preparation and execution of the MOS-C test.

1. 542-424 Detailed Mission Requirements.
2. 542-TE-001 Spacecraft Integration ,Test and Launch Operations Plan.
3. 542-407 Mission Sequence Plan.
4. 542-409 Mission Operations Specification Vol.3 : Operations.
5. 542-409 Mission Operations Specification Vol.5 : Software Interface Specifications (SIS) part 1 and Part2: Operational Interface Agreements (OIA).
6. 542-TS-003 Spacecraft Test Laboratory Users guide.
7. 810-5 DSN Flight Project Interface Design Handbook.
8. 820-13 DSN System Requirements: Detailed Interface Design
9. 542-409 Mission Operations Specification Vol.4 : Procedures
10. MOU MGSM-AT-95-0058 From: Jim Neuman “MOU for ATLO (and MOS-C) Commanding.
11. 542-425 Mission Operations Specification Communications Plan

2.0 CHANGE CONTROL

This document shall be changed only with the specific approval of the MGS Change Control Board (CCB).

3.0 MOS COMPATIBILITY TEST OBJECTIVES

The objectives of the MOS-C test program are to:

a) Validate compatibility of the flight Ground Data System (GDS ver L1.0), including the Deep Space network, with the flight spacecraft and flight software.

b) Validate proper execution of critical flight sequences, defined in section 8.1.1.1 of this document, with the flight spacecraft and flight software.

c) Validate basic Mission Operations System (MOS) flight procedures, and end-to-end dataflow for uplink and downlink for compatibility with the flight spacecraft, and flight software.

d) Validate the Automatic Command Tracking (ACT) software.

e) Benchmark spacecraft behavior for critical sequences for possible future spacecraft anomaly investigation and flight software updates.

f) Validate the interface and compatibility of the Spacecraft Test Laboratory (STL) with the flight software, sequence software, and spacecraft.

4.0 ROLES AND RESPONSIBILITIES

TABLE 1 ROLES AND RESPONSIBILITY FOR THE MOS COMPATIBILITY TESTS.

ROLE	INDIVIDUAL	RESPONSIBILITY	WHERE DURING TEST
Test Conductor-JPL	D. Kiewicz	Coordinate efforts for planning and performing the test. Create MOS-C test product integrated schedule, determine test contents, coordinate the production of the test description/test SOE (timeline), conduct planning/interface meetings, provide status to project, coordinate inputs for mission sequences, review test procedure. Conduct Pre-test briefing. Direct mission sequence test execution in coordination with the LMA Test Director. Verify test objectives are met. Write test report in cooperation with Test Director.	JPL
Test Director-LMA	M. Miller	Write detailed MOS-C procedures, coordinate LMA test inputs, coordinate test dates with respect to ATLO flow, participate in Pre-test briefing. Direct LMA test team activities during the test. Ensure safety of S/C, people, and facility during the test. Edit sequence files (SCMFs) as necessary for ATLO/MOS-C. Write test report in cooperation with Test Conductor. Validate initial conditions prior to each test.	LMA
Mission Planning	W. Sidney	Gather requirements and create Spacecraft Activity Sequence files (SASFs). Coordinate review of sequences and provide high-level verification steps. Verify test constraints and objectives are met.	JPL
NAV Chief	P. Esposito	Generate Nav input files for SPAS and SEQGEN	JPL
SEQ Chief	B. Brooks	Generate sequence products (SSFs, PEFs, and SCMFs) for mission sequences.	JPL
SEGS	G. Vaughan	Produce Sequence of Events (SOE), Spaceflight operations Schedule (SFOS), and DSN Keywordfile.	JPL
STL	K. Starnes	Verify all mission sequences (edited SCMFs) and test sequences prior to running on spacecraft. Provide info about verification to be performed during test.	LMA
RTOT (DSOT)	T. Boreham	Broadcast, distribute, retrieve, and ensure correct storage of the test data in the Project Database (PDB) Ensure correct Decom. Maps are loaded.	JPL
Mission System Manager	S. Dallas	Review test plan, monitor test execution, review test report.	JPL
SCT Chief	J. Neuman	Schedule SCT support for data monitoring and coordinate sequence generation. Review test plan and monitor test execution.	LMA
ATLO Team, H/W PIEs	J. Henk	Verify test setup and execution in high bay. Monitor EGSE while spacecraft powered. Review test procedure, verify test configuration, write and verify flags and redlines.	LMA
SCT Support	Systems,AACS C&DH,Power, Telecom,Prop,Flt S/W	Provide inputs for non-block commands, block parameters, hazardous commands, verification steps, and configuration steps. review all test files. Generate other input files (ephemeris, star catalog). Verify test constraints are not violated. Review test procedure. Verify, in real-time, that all mission sequences perform as expected. Generate test products using appropriate tools from S/C telemetry.	LMA
Instrument Reps	J. Callas R. Springer	Review all test files which affect the instruments. Provide inputs for monitor and control. Monitor instrument performance during the test. Verify in real time that all instruments perform as expected during mission sequences.	JPL
GDS Engineer-JPL	F. Hammer	Oversee and prepare GDS data flow. Establish proper GDS configuration for all MOS Compatible tests. Ensure proper execution during test.	JPL
GDS Engineer-LMA	A. Bucher	Coordinate and prepare GDS data flow. Ensure proper execution during test. Compare data processed at JPL with data processed in Remote MSA.	LMA
R/T Operations Team	B. Hyland	Patch MIL-71 Net to Mars NET, prepare GDS dataflow and ensure proper execution during test. Prepare and deliver coordinated DECOM. Map to DSOT.	JPL
R/T Operations Team	D. Recce	Prepare MIL 71 and the DSN GDS to support MOS testing	JPL

5.0 TEST DESCRIPTION (General)

Two separate test activities are defined.

a) Testing of MOS and S/C compatibility using critical sequences on the spacecraft while it is at the LMA facility in Denver, Colorado

b) End-to-End Testing utilizing the Merritt Island Launch Facility 71 (MIL 71) located at the Kennedy Space Center Merritt Island Launch Area (MILA) while the spacecraft is at the Eastern Test Range (ETR).

During test execution of the aforementioned test, telemetry data will be transmitted to JPL in real-time. In the case of MOS-C tests at LMA, telemetry flow will be via the Telemetry Test and Command System (TTACS). In the case of the End-to-End test at the ETR, telemetry will be transmitted and received via the MIL 71 RF air link and then processed by the DSN Telemetry system.

During the MOS-C testing at LMA, sequences designed and generated by JPL will be loaded on the spacecraft by Assembly Test and Launch Operations (ATLO) personnel at LMA via TTACS and executed at the direction of the JPL Test conductor in coordination with the LMA test director.

During the End-to-End Test at ETR, commands will be transmitted from the AMMOS Command System at JPL to the spacecraft for execution via the MIL 71 RF link.

In general the tests will be executed as follows.

a) Validate sequences by execution on the Spacecraft test laboratory (STL)

b) Perform the standard spacecraft power-on procedure

c) Verify the spacecraft initial conditions and ground support configuration

d) Verify required test participants are ready

e) Verify 2KBPS engineering data is flowing to JPL (RTOT) and LMA Mission support Area (MSA). For tests involving S & E data modes, verify data flow to the SOPCs.

f) Load and execute specified sequence(s) on the spacecraft (see Test Products in section 8.0 of this document)

g) Verify results in real-time

h) Perform the standard power-down procedure *

i) Perform post-test(s) analysis

j) Prepare the test report (see Test Products in section 8.0 of this document)

* Unless the ATLO schedule requires spacecraft power to remain on to support follow-on testing

5.1 Pass Fail Criteria

GENERAL PASS/ FAIL CRITERIA:

For all sequences tested for MOS-C, the term “validation” shall mean confirmation that all valid commands executed at the required times and produced the intended effect on the commanded device using the GDS L1.0 software and deliverables. For those commands designated as restricted (e.g., pyro valve actuation, thruster or main engine valve actuation, gimbal actuation, etc.), confirmation of the electrical command signal at the CIU/CIX interface to the device shall constitute command validation.

S02 SEQUENCE (MOI):

1. Validate safe mode disable and SCP machine fault exception inhibit commands executed.

2. Validate execution of the pre-MOI partial pressurization (i.e., regulator checkout) event:

   a) Switch to LGA, MOT telemetry modulation turned off and non-coherent mode enabled
   b) Catalyst bed heaters turned on
   c) Skew RWA powered on
   d) Spacecraft acquires required ISH/Deploy control mode attitude
   e) Deploy attitude control mode acquired, RWA tach hold mode initiated and thruster control initiated
   f) Overpressure fault protection enabled
   g) Pyro Valve 4 opened to begin system pressurization
   h) Latch Valve 1 closed 10 seconds after PV4 opened
   i) Resumption of RWA control and reacquisition of ANS.
   j) Catalyst bed heaters turned off and thrusters disarmed
   k) Switch back to HGA, MOT telemetry modulation turned on and non-coherent mode disabled
   l) Skew RWA powered off

3. Validate Latch Valve 1 reopened to fully pressurize propulsion system

4. Validate contingency mode disarm and sun monitor ephemeris check disable commands executed

5. Validate execution of the MOI maneuver in the T1-C load

   a) 2 kbps EDF telemetry recording initiated on SSR 1A
   b) TWTA beam turned off
   c) Spacecraft acquires desired burn attitude within the required slew allocation
   d) Solar arrays acquire correct positions for maneuver
   e) Catalyst bed heaters and main engine flange (injector) heaters turned on
   f) Gyro short circuit recovery disabled
   g) IMU switched from “all gyro” format to “accelerometer” format, IMU frozen gyro check enabled, and accelerometer null bias calibration performed
   h) Latch valves 4 and 5 opened
   i) Underpressure fault protection enabled

j) Flight software maneuver task initiates Main Engine maneuver at the required time and terminates the maneuver upon achieving the desired delta V
k) Flight software maneuver task performs pitchover steering throughout burn
l) Catalyst bed heaters and main engine flange (injector) heaters turned off, ME and thrusters disarmed and disabled
m) Safe mode, contingency mode, sun monitor ephemeris check, machine fault exception and gyro short recovery re-enabled upon completion of the burn
n) Underpressure fault protection disabled
o) IMU switched back to "all gyro" format and frozen gyro check disabled
p) Pitchover rate zeroed out
q) ANS reacquired
r) Solar arrays acquire nominal cruise positions
s) TWTA beam turned on
t) Playback of MOI data from SSR 1A at 8 kbps

AEROBRAKING SEQUENCE:

1. Validate the execution of the first drag pass.

a) TWTA beam turned off and 2 kbps EDF telemetry recording initiated on SSR 1A
b) Catalyst bed heaters turned on
c) Spacecraft acquires desired initial nadir attitude within the required slew allocation
d) Solar arrays acquire required positions for the drag pass
e) CSA/BU AACS mode, RWA tach hold mode and thruster control are initiated at start of drag pass
f) Maintain required nadir pointing through the drag pass using preloaded mapping ephemeris
g) Star processing disabled
h) Beginning of drag pass, end of drag pass and drag pass reset commands executed and appropriate thruster gains set per drag pass phase
i) RWA wheel speeds zeroed at periapsis
j) Resumption of RWA control after drag pass
k) Catalyst bed heaters turned off and thrusters disarmed
l) ANS reacquisition and star processing reenabled
m) TWTA beam turned on
n) Playback of drag pass data from SSR 1A at 21 kbps.

2. Validate the execution of the ABM maneuver

a) TWTA beam turned off and 2 kbps EDF telemetry recording initiated on SSR 1A
b) Catalyst bed heaters turned on
c) Spacecraft acquires desired burn attitude within the required slew allocation
d) Solar arrays acquire required positions for the burn
e) IMU switched from "all gyro" format to accelerometer format, frozen gyro check enabled and accelerometer null bias measurement performed
f) Flight software maneuver task initiates maneuver at the required time and terminates the maneuver upon achieving the desired delta V
g) Catalyst bed heaters turned off and thrusters disarmed
h) IMU switched back to "all gyro" format and frozen gyro check disabled
i) ANS reacquired
j) TWTA beam turned on
k) Playback of drag pass data from SSR 1A at 21 kbps.

3. Validate the execution of the second drag pass.

a) TWTA beam turned off and 2 kbps EDF telemetry recording initiated on SSR 1A
b) Catalyst bed heater turn on
c) Spacecraft acquires desired initial nadir attitude within the required slew allocation
d) Solar arrays acquire required positions for the drag pass
e) CSA/BU AACS mode, RWA tach hold mode and thruster control are initiated at start of drag pass
f) Maintain required nadir pointing through the drag pass using preloaded mapping ephemeris
g) Star processing disabled
h) Beginning of drag pass, end of drag pass and drag pass reset commands executed and appropriate thruster gains set per drag pass phase
i) RWA wheel speeds zeroed at periapsis
j) Resumption of RWA control after drag pass
k) Catalyst bed heaters turned off and thrusters disarmed

l) Acquisition of post drag pass ANS set up attitude for CSA FOV
m) ANS reacquired and star processing reenabled
n) TWTA beam turned on
o) Playback of drag pass data from SSR 1A at 21 kbps.

S01 SEQUENCE (S/C Post-Launch Checkout and TCM1):

1. Verify compatibility between S/C separation sequence final conditions and the assumed initial conditions for the S01 sequence.

2. Validate execution of the pre-TCM1 propulsion system priming event:

   a) Main Engine valves armed, enabled and opened for 30 seconds
   b) Latch Valves 4 and 5 armed, enabled and opened for 30 seconds

3. Validate execution of the pre-TCM1 partial pressurization (i.e., regulator checkout) event:

   a) Catalyst bed heaters turned on
   b) Skew RWA powered on
   c) Spacecraft acquires required ISH/Deploy control mode attitude
   d) Deploy attitude control mode acquired, RWA tach hold mode initiated and thruster control initiated
   e) Overpressure fault protection enabled
   f) Pyro Valve 6 opened to begin system pressurization
   g) Latch Valve 1 closed 10 seconds after PV6 opened
   h) Resumption of RWA control and reacquisition of ANS.
   i) Catalyst bed heaters turned off and thrusters disarmed
   j) Skew RWA powered off

4. Validate Latch Valve 1 reopened to fully pressurize propulsion system

5. Validate execution of the TCM-1 maneuver in the C1-E load

   a) 2 kbps EDF telemetry recording initiated on SSR 1A
   b) TWTA beam turned off
   c) Spacecraft acquires desired burn attitude within the required slew allocation
   d) Solar arrays acquire correct positions for maneuver
   e) Catalyst bed heaters and main engine flange (injector) heaters turned on
   f) IMU switched from "all gyro" format to "accelerometer" format, IMU frozen gyro check enabled, and accelerometer null bias calibration performed
   g) Latch valves 4 and 5 opened
   h) Flight software maneuver task initiates Main Engine maneuver at the required time and terminates the maneuver upon achieving the desired delta V
   i) Catalyst bed heaters and main engine flange (injector) heaters turned off. Main Engine and thrusters disarmed and disabled
   j) IMU frozen gyro check disabled upon completion of burn
   k) ANS reacquisition
   l) Solar arrays acquire nominal cruise positions
   m) TWTA beam turned on
   n) Playback of MOI data from SSR 1A at 8 kbps

6. Validate post -TCM1 pressurant isolation in the C1-F load.

a) Catalyst bed heaters turned on
b) Skew RWA powered on
c) Spacecraft acquires required ISH/Deploy control mode attitude
d) Deploy attitude control mode acquired, RWA tach hold mode initiated and thruster control initiated
e) Pyro Valve 6 opened to begin system pressurization
f) Latch Valve 1 closed 10 seconds after PV6 opened
g) Overpressure fault protection disabled
h) Resumption of RWA control and reacquisition of ANS.
i) Catalyst bed heaters turned off and thrusters disarmed
j) Skew RWA powered off

S04 SEQUENCE (Mapping Deployment):

1. Validate execution of the NTO isolation event:

   a) Switch to LGA, MOT telemetry modulation turned off and non-coherent mode enabled
   b) Catalyst bed heaters turned on
   c) Skew RWA powered on
   d) Spacecraft acquires required ISH/Deploy control mode attitude
   e) Deploy attitude control mode acquired, RWA tach hold mode initiated and thruster control initiated
   f) Pyro Valve 10 closed to isolate NTO
   g) Resumption of RWA control and reacquisition of ANS.
   h) Catalyst bed heaters turned off and thrusters disarmed
   i) Switch back to HGA, MOT telemetry modulation turned on and non-coherent mode disabled

2. Validate execution of the HGA deployment event

   a) HGA cable and hinge damper heaters powered on
   b) Catalyst bed heaters turned on
   c) Switch to LGA, MOT telemetry modulation turned off and non-coherent mode enabled
   d) Skew RWA powered on
   e) Spacecraft acquires required ISH/Deploy control mode attitude
   f) Solar arrays acquire HGA deployment positions
   g) Deploy attitude control mode acquired, RWA tach hold mode initiated and thruster control initiated
   h) HGA release burn wires fired to deploy HGA boom
   i) Resumption of RWA control and reacquisition of ANS.
   j) MOT telemetry modulation turned on, EDF set to Emergency mode and 10 bps downlink initiated
   k) CDUs configured for 7.8125 bps uplink
   l) Solar arrays reacquire nominal cruise positions
   m) HGA GDE electronics powered on and HGA GDE redundancy management logic enabled
   n) HGA rotated to Earth point position
   o) Resumption of RWA control
   p) Catalyst bed heaters turned off and thrusters disarmed
   q) ANS reacquired
   r) Skew RWA powered off

s) Switch to HGA, turn MOT telemetry modulation on, disable non-coherent mode, EDF to Engineering mode, 2 kbps downlink initiated and the CDUs set back to 125 bps uplink

3. Validate execution of the Mapping pre-configuration activity

    a) MHSA powered on and its redunancy managment logic and thermal monitoring enabled
    b) Mapping MHSA and CSA Backup modes enabled
    c) Mapping ephemeris logic enabled

4. Validate setting of SCU latch relay for mapping phase via realtime command initiation

5. Validate setting of Flight software parameters required for mapping operations via realtime command initiation

    a) Mapping phase RWA PID gains loaded
    b) Mapping phase sun pointing targets selected (for use in contingency mode)
    c) Updated Moments of Inertia dyadic loaded
    d) HGA and SA rewind parameters loaded

6. Validate execution of the mapping configuration (MAPFIG block) event

    a) Spacecraft acquires desired initial nadir attitude within the required slew allocation
    b) Solar arrays and HGA acquire set up positions for enabling autonomous tracking
    c) CSA/BU mode offset (used for aerobraking) disabled
    d) Nadir pointing maintained in CSA/BU mode using the new pre-loaded mapping ephemeris and stars properly identified using the new pre-loaded star catalogue
    e) Autonomous HGA and SA gimbal drive tracking enabled and working properly

7. Validate acquisition of Mapping Primary mode via realtime command initiation

S05 SEQUENCE (Mapping Sequence):

1. Validate Payload activation events

    a) PDS powered on and put into EOM mode
    b) EDF set to mission mode and XSU configured for 4 ksps realtime downlink
    c) SSR 1A powered on and configured to record 4 ksps telemetry from the PDS for 6 hours
    d) PDS write protect bits turned off and the PDS RAM loaded via realtime command initiation
    e) PDS write protect bits turned off and MRO of PDS memory performed via realtime command initiation
    f) PDS commanded to transfer from PROM to RAM and PDS mode set to LRC via realtime command initiation
    g) MAG side A powered on
    h) ER powered on
    i) MOC side B powered on and PDS configured to listen to MOC BIU side B
    j) MOLA powered on
    k) TES powered on
    l) MR powered on

2. Validate enabling and autonomous activation of the on-board equator crossing PDS broadcast command

3. Validate enabling of the Autonomous Eclipse Management (AEM) egress logic and autonomous activation of the on-board ER mapping configuration script

4. Validate HGA is unparked and positioned for initiation of autonomous tracking upon occultation egress

5. Validate enabling of the AEM ingress logic and autonomous activation of the on-board mapping data return script for the realtime 40 ksps S&E-2 orbit:

   a) Mapping Data Return script activation at eclipse ingress
   b) TWTA beam turned on
   c) MOT telemetry modulation turned off and non-coherent mode enabled for radio science at egress
   d) Autonomous SA tracking disabled for radio science
   e) MOT telemetry modulation turned on and non-coherent mode disabled ending radio science at egress
   f) Autonomous SA tracking enabled after radio science
   g) PDS and XSU configured for S&E-2 40 ksps realtime data return
   h) PDS and XSU configured for S&E-1 4 ksps realtime data return
   i) MOT telemetry modulation turned off and non-coherent mode enabled for radio science at ingress
   j) Autonomous SA tracking disabled for radio science
   k) MOT telemetry modulation turned on and non-coherent mode disabled ending radio science at ingress
   l) Autonomous SA tracking enabled after radio science
   m) TWTA beam turned off

6. Validate HGA and SA rewind during eclipse

7. Validate enabling of the AEM ingress logic and autonomous activation of the on-board mapping data return script for the 21 ksps SSR playback orbit:

   a) Mapping Data Return script activation at eclipse ingress
   b) TWTA beam turned on
   c) MOT telemetry modulation turned off and non-coherent mode enabled for radio science at egress
   d) Autonomous SA tracking disabled for radio science
   e) MOT telemetry modulation turned on and non-coherent mode disabled ending radio science at egress
   f) Autonomous SA tracking enabled after radio science
   g) XSU and SSR 1A configured for 21 ksps playback
   h) XSU configured for S&E-1 4 ksps realtime data return upon completion of playback
   i) MOT telemetry modulation turned off and non-coherent mode enabled for radio science at ingress
   j) Autonomous SA tracking disabled for radio science
   k) MOT telemetry modulation turned on and non-coherent mode disabled ending radio science at ingress
   l) Autonomous SA tracking enabled after radio science
   m) TWTA beam turned off

8. Validate HGA parked at end of playback orbit into the minimum momentum buildup position

6.0 GDS TEST CONFIGURATION

6.1 MOS Compatibility

6.1.1 Test Location:

Space Simulation Building, Denver and JPL.

6.1.2 Data Flow

Uplink:

Uplink products, Spacecraft Activity Sequence Files (SASF), Spacecraft Command Message Format (SCMF), and Predicted Events File (PEF) etc., will be generated and placed on the PDB using flight tools and procedures. The SCMFs will be retrieved from the PDB by the ATLO Test Director (TD), modified if necessary, and transmitted to the spacecraft via the Spacecraft Checkout Complex (SCC) Test Telemetry and Command System (TTACS).

Downlink:

Spacecraft telemetry data will be routed to the TTACS for frame synchronization and Standard Formatted Data Unit (SFDU) encapsulation, and then forwarded to the flight Telemetry Input System (TIS) and the PDB. Spacecraft engineering data will be monitored in real-time by the JPL Mission Controllers, the Spacecraft support personnel at JPL and the Spacecraft Team at Denver. As appropriate, Science instrument data packets will be retrieved by the SOPCs and engineering "I" channels will be monitored at JPL by Experiment Representatives and remote science sites. Engineering telemetry products will be produced and validated via Spacecraft Team use of the Spacecraft Performance Analysis System (SPAS) to the maximum extent possible.

Figure 1 shows the functional data flow from the S/C during MOS-C testing at LMA

6.1.3 Voice Communications

Table 2 provides an overview of the required voice communications and circuit assignments for MOS-C testing. For a detailed communications description refer to the appropriate MOS-C test procedure, or the appropriate test sequence of events (SOE).

6.2 End To End

6.2.1 Test Location:

Payload Hazardous Servicing Facility (PHSF) Facility, Eastern Test Range, MIL 71, LMA Denver, and JPL.

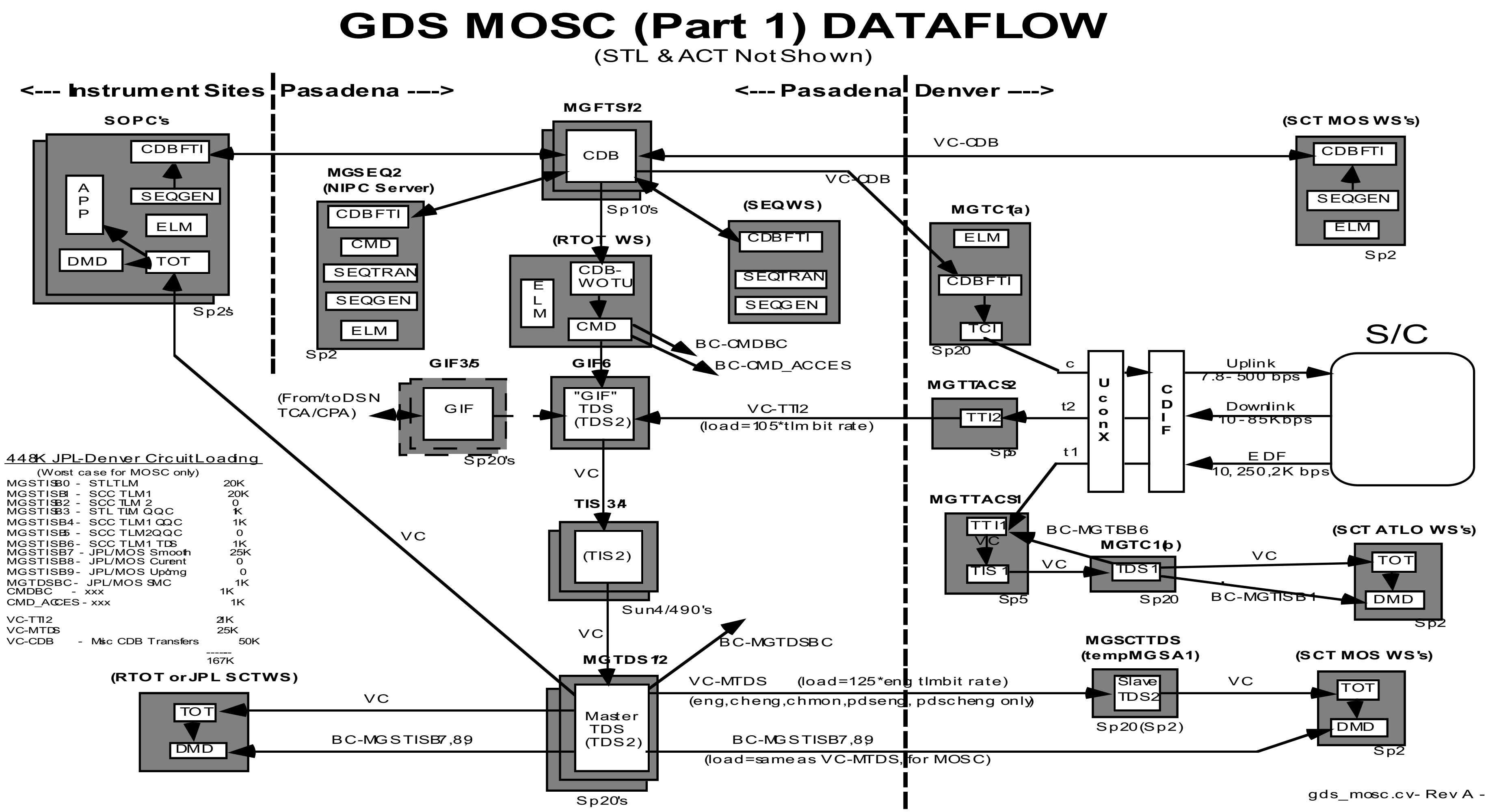

Figure 1 MOS-C Data Flow at LMA

6.2.2 Data Flow

Uplink:

Ground Command (GCMD) files will be generated and placed on the PDB using flight tools and procedures. The Mission Control Engineer will transfer and radiate command messages via the RF airlink from the MIL 71 command system to the spacecraft.

Downlink:

The spacecraft will radiate telemetry to MIL 71 via the RF airlink. MIL 71 will convolutionally decode, frame-sync and route Standard Format Data Unit (SFDU) telemetry to the flight TIS at JPL via the Ground Communication Facility (GCF).

As appropriate, Science Instrument data packets will be retrieved from the PDB by the SOPCs and engineering " I " channels will be monitored at JPL by Experiment Representatives and remote science sites. Engineering telemetry products will be produced and validated via Spacecraft Team use of SPAS.

Figure 2.0 contains a basic system block diagram of the launch phase GDS.

Table 2 provides an overview of the required voice communications and circuit assignments required for MOS-C testing. For a detailed communications description refer to the appropriate MOS-C test procedure, or SOE.

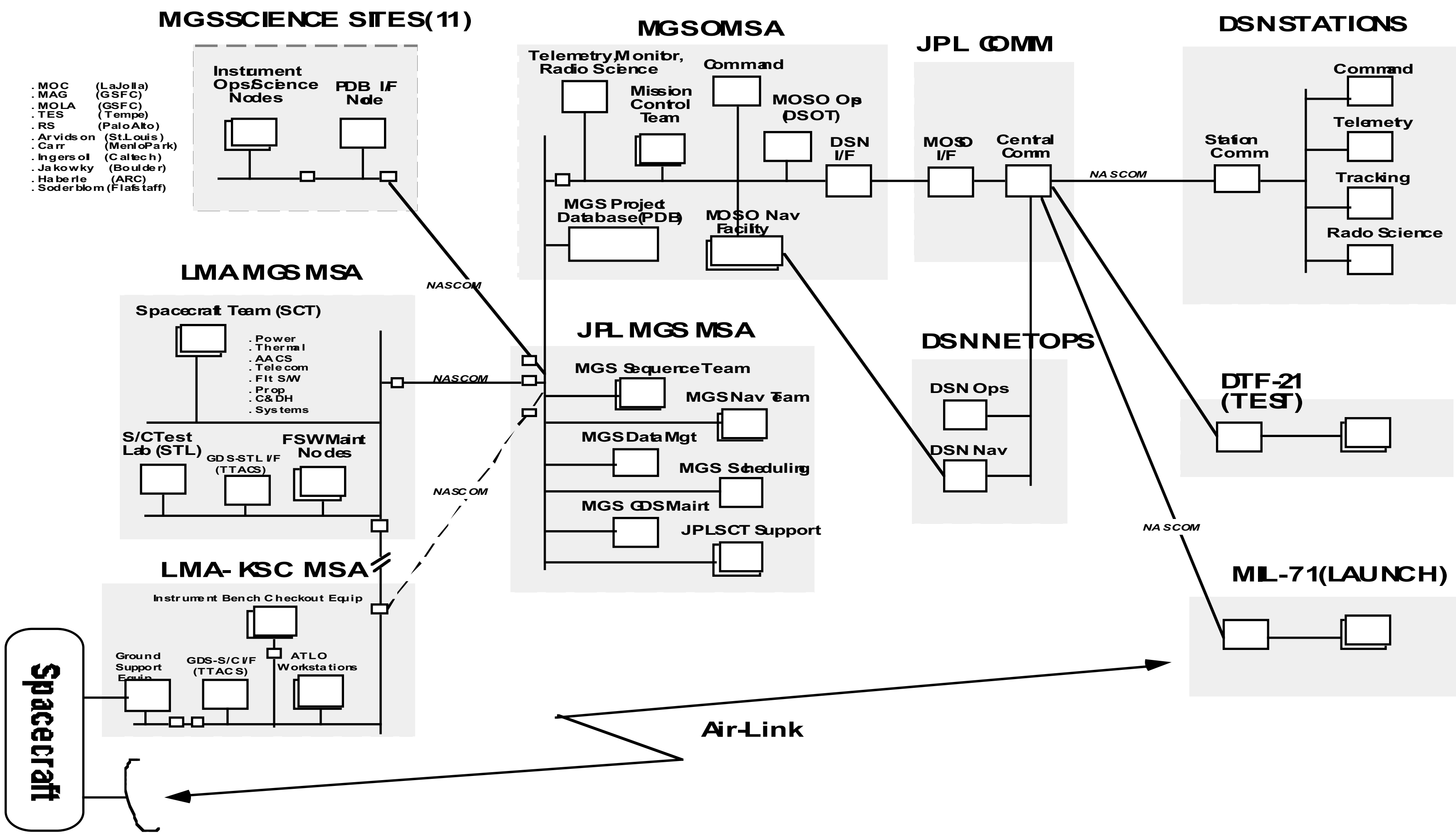

Figure 2 Basic GDS Configuration

ROLE	INDIVIDUAL	Voice Communication Assignment	WHERE DURING TEST
Test Conductor-JPL	D. Kiewicz	1,2,3,4,5,6,7,8,9	JPL
Test Director-LMA	M. Miller	1,2,3,4,5,6,7,8	LMA
Mission Planning	W. Sidney	3	JPL
NAV Chief	P. Esposito	3	JPL
SEQ Chief	B. Brooks	3	JPL
STL	K. Starnes	4	LMA
RTOT (DSOT)	T. Boreham	1	JPL
Mission System Manager	S. Dallas	2,3	JPL
SCT Chief	J. Neuman	3,4	LMA
ATLO Team, H/W PIEs	J. Henk	3,4	LMA
SCT Support	Systems, AACS,C&DH Power, Telecom,Prop,Flt S/W	3,4 4 4	LMA
Instrument Reps	J. Callas R. Springer	5	JPL
GDS Engineer-JPL	F. Hammer	3	JPL
GDS Engineer-LMA	A. Bucher	3,4	LMA
R/T Operations Team	B. Hyland	1,2,3,4,5,6	JPL

Table 2 Voice Communication assignments

6.3 Voice Circuit Description

The following descriptions provide an overview of the voice communication circuits, their assigned names and appropriate usage. This description should be considered a guideline, and changes may be necessary due to equipment limitations or circuit requirements at the time of the test. Refer to the appropriate MOS-C test procedure for detailed assignments.

MOS-C Test Communication Configuration At LMA

1. **INTER-2**
   Used for communication and coordination between the Mission Controller, Data Control and JPL Comm.

2. **TEST-6**
   Used by the test conductor to coordinate test activities.

3. **MARS COORD**
   Used for communication and coordination between the Mission Controllers and all other operations teams (SCT, NAV, SEQ, etc.).

4. **MARS OPS**
   Used by the spacecraft team at LMA for communication and coordination of team activities during MOS-C testing.

5. **MARS SCI**
   Used by the Science Teams for communication and coordination between all PIs and ERs. This net may be also used for instrument integration and contact with the mission controllers during this test.

MOS-C Test Communication Configuration At ETR

6. **MARS NET**
   Will be patched to MIL-71 for coordination of data flow and command activities as required.

7. **S/C Test Conductor:**
   Used by the spacecraft team at LMA for communication and coordination of team activities during MOS-C testing. (Same as MARS OPS at LMA test)

8. **MGS Data:**
   Used for communication and coordination between the mission controllers and all other operations teams (SCT, NAV, SEQ, etc.). (Same as MARS COORD at LMA test)

9. **MGS Management:**
   Used by the Test conductor to coordinate test activities.

7.0 RELATIONSHIP TO OTHER TESTS

The sequences used during the MOS-C tests at LMA will have been used throughout the ATLO activity which may satisfy a portion of the objectives defined herein. JPL will continually review the results of these ATLO tests to determine the need for further testing on the spacecraft during the period set aside for MOS-C testing. The End-to-End testing at KSC is unique in that it is the only test planned using DSN equipment in a flight-like configuration and will be conducted independently of the MOS-C and ATLO testing at Denver.

8.0 TEST PRODUCTS

Many products will be generated before and after these tests are conducted. The schedule in Section 10.0 includes all the products required in order to plan and generate the critical spacecraft sequences. This schedule should only be used as an overview for ATLO and MOS-C activities. The dynamic environment that exists in ATLO requires this schedule to be updated on a continuing basis. This schedule will be updated frequently and should be replaced upon issuance.

Products generated during STL runs of the sequences should be saved for comparison with those run on the spacecraft. Defined here are those products specifically required to execute the sequence tests and to provide test results. Section 5.1 of this document provides the detailed pass fail criteria for the following sequences.

8.1 Pre-test Products

8.1.1 Sequences

8.1.1.1 LMA MOS-C Test

Four critical sequences have been identified for execution on the spacecraft as part of the MOS-C test at LMA. These sequences will be modified by LMA personnel, if necessary, to prevent the execution of hazardous commands or commands not compatible with the spacecraft configuration at the time of the test. The modifications/deletions or omissions will be documented as part of the post test report.

The four test sequences are:

a) MOI
b) Aerobraking
c) Propulsive Maneuver (TCM-1)
d) Map Deploy/Payload C/O

These sequences are described in detail in the Mission Sequence Plan, which includes a general description, initial conditions table, timeline and SASF for each of the critical sequences above. The following is a brief summary level description of each of these sequences.

a) MOI

The T1 sequence starts at MOI-7 days and extends to MOI+2 days. The sequence consists of three loads. Load A executes from MOI-7 to MOI-5 days and brings the primary regulator back on line to confirm its proper operation. Load B executes from MOI-5 to MOI-2 days to fully pressurize the propulsion system in preparation for MOI. Load C contains the actual maneuver sequence itself and executes from MOI-2 to MOI+2 days.

b) AEROBRAKING

The AEROBRAKING sequence represents a two orbit period sequence of normal aerobraking activities. The orbit period for the sequence is two hours. The sequence consists of "trigger" commands which initiate a pre-loaded reusable utility script. The trigger command executes at the required time prior to periapsis, initiating the pre-loaded script, and configures/orients the spacecraft for the drag pass. The sequence will contain two of these trigger commands executed over two consecutive orbits. The sample aerobraking test sequence will also consist of an ABM maneuver performed at the second apoapsis. Similar to the drag pass periapsis script, the ABM command script is a pre-loaded reusable utility script. The real-time trigger command is sent to the spacecraft by the ground operations team.

c) PROPULSIVE MANEUVER (TCM-1)

The C1 sequence is the post-launch checkout and TCM-1 sequence. The sequence starts at L+2 days, extends to L+18 days and consists of six loads. Load A executes from L+2 to L+6 and contains the playback of the recorded launch telemetry. Load B executes at L+6 days to vent and wet the bipropellant lines. Load C executes at L+8 days to partially pressurize the propulsion system in order to verify the operation of the primary regulator. Load D executes at L+10 days to completely pressurize the propulsion system in preparation for TCM-1. Load E contains the TCM-1 maneuver itself and executes at L+15 days. Finally load F is executed at L+17 days to isolate the helium pressurant for the remainder of the cruise phase until MOI.

d) MAPPING DEPLOY/ MAPPING CHECK OUT

The T7 sequence is performed to configure the spacecraft for mapping operations. The sequence starts at ABX+40 days and is 10 days in duration. The sequence consists of three loads. Load A performs the NTO isolation and the HGA deployment and calibration. Load B executes at ABX+44 to command the spacecraft to the mapping nadir pointed attitude control state. Load C executes at ABX+47 to power on the instruments and perform a two day mapping rehearsal.

It should be noted that these scripts will also be used extensively during ATLO and will be optimized prior to MOS-C by the removal of hazardous commands and "dead time" in the sequence.

8.1.2 Test Descriptions/Scripts

For each MOS-C sequence to be run on the spacecraft, a test script will be written. The test script at a minimum shall contain:

a) Sequence/Test ID.
b) Scheduled date and time of the test.
c) Test participants
d) Test products/files (by specific name) to include deliverables and receivables.
e) Test configuration, including detailed voice communication and monitoring requirements/procedures.
f) Specific steps required beyond those in the test sequence.
g) Pass/Fail criteria for the scheduled test.

8.2 Post-test Products

Post test reports shall be written to contain at least the following.

a) Sequence/Test ID.
b) Post-test Analysis results.
c) Deviations from script and/or sequence.
d) Failures/Anomalies.
e) Pass/fail conclusion.

A set of files, input and output, shall be catalogued and archived after each test.

9.0 END-TO-END (ETE) COMPATIBILITY TEST

9.1 INTRODUCTION

The DSN and MOS-C End-to-End Tests are performed at the Kennedy Space Center (KSC) while the spacecraft is located at the KSC PHSF. The purpose of this activity is to demonstrate the end-to-end command and telemetry portions of the MGS GDS including DSN command and telemetry.

The JPL Mission Operations System will communicate with the spacecraft through MIL 71 for command and telemetry. The spacecraft may be configured using real-time Pre-Approved Commands (PAC's) and by specially prepared mini-sequences that will configure TWTA, SSR and selected data rates utilizing the COMM and SSRMGR blocks from the Mission Sequence Team. These mini-sequences are subject to review and approval by the LMA Test Director to insure spacecraft and personnel safety.

Currently there are 3 days/72 hours set aside in the schedule to complete all ETE testing.

9.2 PURPOSE

The purpose of these tests are to validate DSN Radio Frequency (RF) compatibility with the spacecraft and extend the MOS-C Test, to include DSN GDS segments of the uplink and downlink at MIL 71 for a complete end-to-end test using the entire MGS mission system.

9.3 TEST ENVIRONMENT

The spacecraft bus and payload are required to be in their operational configuration (subject to safety and environmental limitations) for these tests. The spacecraft RF radiation tests, to include the X-Band and Mars Relay downlinks during this period, will only be performed after authorization is obtained by the KSC Frequency Coordination Office.

9.4 TEST CONFIGURATIONS

These capabilities are required for the duration of the MOS-C ETE test program at the launch site.

- MIL 71 in a DSN operational configuration by August 1996. Augmented by the Compatibility Test Trailer (CTT 22) for I/F verification to the Block V Receiver.
- All voice data circuits between PHSF, MIL 71, CTT 22, JPL and the LMA to be Operational.
- The MGS spacecraft should be in the Launch Configuration.

The GDS configuration for the DSN and MOS-C ETE test is provided in Figure 3. For a detailed configuration description, please see the ETE test procedure(s).

9.4.1 Telemetry Data

Telemetry data flow from the spacecraft to JPL Mission Operations/LMA will be via RF airlink to MIL 71, and via hardline from the Payload Hazardous Servicing Facility to MIL 71. The following data rates shall be tested for both Playback and Real-time configurations, all applicable modulation indices, and subcarrier combinations,

10 bps, 2 Kbps, 21.3 Kbps, 40 Kbps, 80 Kbps (R/T), and 85.3 Kbps (P/B) at 21.333kHz and 320kHz subcarrier frequencies.

Additionally all Solid State Recorder (SSR) combinations shall be excersized.

The MGS Real-time Operations Team (RTOT) will monitor all telemetry data products to include the following DSN generated data blocks and interfaces to insure correct reception and processing of the MGS 820-13 DSN Detailed Interface Design modules listed below,

MON 5-15, and TLM 3-20

The Spacecraft Team (SCT) shall be responsible for evaluating all engineering data. Where applicable, the Science Operations Project Centers (SOPC) shall be responsible for query and validation of science packets for their respective instrument to insure packet integrity.

9.4.1.1 RF Link

The DSN will provide uplink carrier with command and ranging modulation to the spacecraft. The spacecraft will provide RF downlinks containing telemetry and radiometric information compatible with the 810-5 DSN Flight Project Interface Design Handbook, and appropriate 820-13 DSN System Requirements: Detailed Interface Design modules. All output power and path loss measurements will be made prior to the start of ETE testing. These measurements will provide a baseline for evaluating the performance of the S/C to DSN interfaces.

9.4.1.2 Hardline

The PHSF S/C RF and Telemetry output which will contain RF modulation with raw spacecraft telemetry data, shall be compatible with the 810-5 DSN Flight Project Interface Design Handbook standards.

9.4.2 Command Data

Command data flow from JPL Mission Operations to the spacecraft will be via RF airlink with MIL 71. The MGS RTOT will send Pre-Approved Commands (PAC's) and sequences as required to re-configure the MGS S/C to support ETE testing. The commands shall be uplinked through both S/C receivers via hardlink and airlink paths as appropriate.

It is also desirable to perform a command threshold check for each receiver and Command Detector Unit (CDU) combination. This test will serve as a baseline for in-flight performance and possible anomaly investigation efforts should they be required.

9.4.2.1 Command Data Rate Test

The following U/L command data rates shall be exercised,

7.8125 bps, 125 bps, 250 bps, and 500 bps at a 16kHz subcarrier frequency.

It is highly desirable to perform as many commands as possible at each rate utilizing either "real" commands or NOP's.

The RTOT will send commands, verify the correct reception by the S/C of the command via the SCT analysis of the telemetry data, and validate the MGS 820-13 DSN Detailed Interface Design module CMD 4-6 with the DSN Command Processor Assembly (CPA) by insuring that all functions of the MGS Command workstation work correctly with the DSN command system.

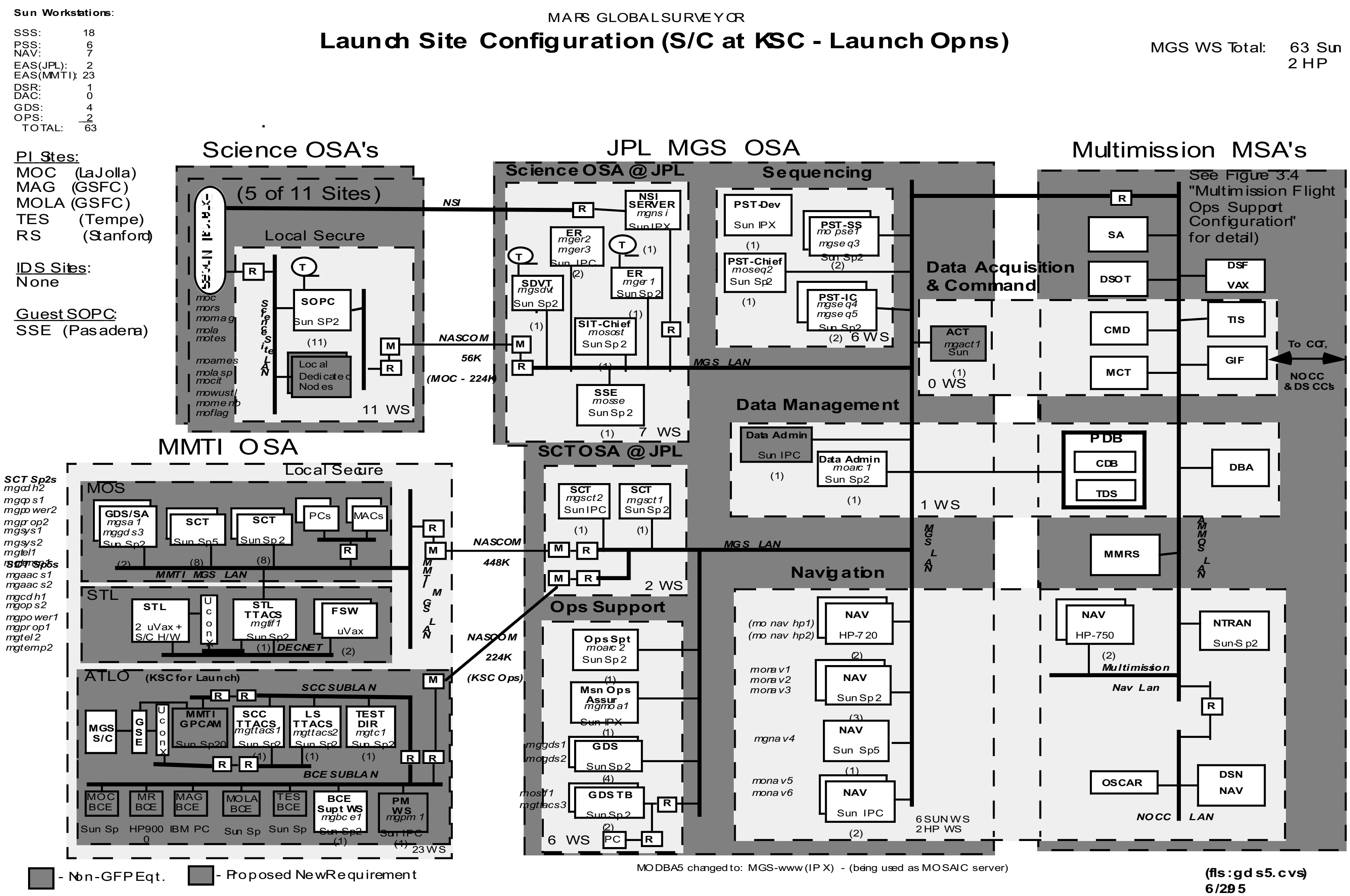

Figure 3 MOS-C GDS Configuration S/C at ETE

9.5 TEST DESCRIPTION

The JPL Mission Operations System will communicate with the spacecraft through MIL 71 for both command and telemetry. The spacecraft will cycle through data modes and rates by executing a prescribed set of Mini sequences produced by the Mission Operations System. These mini-sequences shall be a subset of the Mission Operations Compatibility Test sequences utilizing the COMM and SSR _MGR blocks to cycle the S/C through applicable R/F configurations and data modes as previously specified in this section.

9.5.1 Spacecraft Mode Tests

The Spacecraft should provide a minimum of 15 minutes of Science & Engineering (S&E-1&2) and Engineering transfer frames for each XSU data mode and rate including solid state recorder playback of the 85.3Ksps data rate, in order to perform a meaningful test of the GDS. Also, the engineering data rate of 10 bps should be provided for a minimum of 30 minutes.

All test duration times given are approximate and exclude set-up or spacecraft reconfiguration time.

9.6 TEST ACCEPTANCE CRITERIA

From an end-to-end Uplink and Downlink perspective the tests shall demonstrate that the JPL Mission Operations System and the DSN GDS can generate and successfully transmit commands, perform sequence loads compatible with the spacecraft, and process spacecraft telemetry and radiometric data in accordance with all applicable interface agreement's. Also the spacecraft should conform to the pass-fail criteria set forth in section 5.1 of this document as applicable.

9.6.1 RF Link and Mission Operations Check

After the functional electrical tests have been completed, an RF test will be performed using a microwave link to MIL 71. This test will be a verification/recertification that the JPL Mission Operations System, including the DSN GDS at MIL 71, can process spacecraft telemetry.

9.6.2 Hazardous Command Protection

Hazardous command protection is the responsibility of the LMA Test Director. All sequences will be edited for hazardous commands and reviewed by the Test Director prior to being uplinked to the spacecraft using the procedures outlined in MOU MGSM-AT-95-0058; From Jim Neuman, Subject:"MOU for ATLO (and MOS-C) Commanding"

10.0 SCHEDULE

The schedule of products and activities required to support MOS Compatibility testing are shown in the following MOS-C integrated schedule. Again the dynamic environment that exists in ATLO requires this schedule to be updated on a continuing basis. This schedule will be updated frequently and should be replaced upon issuance.

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